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SOIL-INHABITING ARTHROPODS AS INDICATORS OF ENVIRONMENTAL QUALITY*

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Abstract. Soil-inhabiting arthropods such as Collembola, Cryptostigmata and termites as indicators of various environmental gradients and air pollution, being considered both as biotic indices and bioassay monitors, are reported and discussed.

Keywords: Soil-arthropods–Collembola–Cryptostigmata–termites–bioindicators

Introduction: an appraisal

The organisms, in nature, closely interact with the abiotic environmental factors which synergistically influence their activities. Thus, many of them respond proportionally even to minute changes in the environment, and are easily monitored. However, certain species, populations and communities of organisms provide clues to the alterations in the environmental quality more quickly and precisely than any other method [11]. They can be used as indicators for environmental quality — the state of measurable components of the environment or its beauty and worth, and known as bioindicators of environmental quality. Unfortunately, these organisms are frequently overlooked or neglected in the environmental monitoring programmes probably because of the difficulties in interpretation of the information they provide. The environmental information recorded by them continually in nature is yet be or rarely recognised.

According to Lincoln et al. [16], "Bioindicator is a species of organism, the presence or absence of which is indicative of a particular habitat, community or set of environmental conditions". The term bioindicator should be strictly reserved for those organisms which are sensitive enough to react to any alternations in the natural environment. They should be recognised through keen observations in nature tracing their correlationships with the changed environmental conditions. Nevertheless, there should be standardization of

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methods for recognising and designating organisms seen in the nature, as bioindicators of environmental quality. It has been stated that several populations or groups of species are better bioindicators compared to a single species [20, 25]. Large and long-lived organisms indicate the environmental quality better than smaller organisms. Besides, the organisms with narrow tolerance range are known as better indicators than that with wide tolerance range. Moreover, good bioindicators have narrow ecological valency and are stenotopic being bound strictly to a particular biotope.

There are two approaches such as biotic indices and bioassay monitors used for detecting and designating organisms as bioindicators of environmental quality, the former pertaining to the multiple species analyses and the latter to single species analysis. The concept of specific organism as indicator of environmental quality is very old dating back to 1880 when Von Fritch described *Klebsiella pneumonia* as indicator organisms of human faecal contamination. The merits and demerits of these two approaches were compared briefly [3], and it was stated that the biotic indices are based on organisms studied *in situ* while the bioassay monitors are transferred to the study site for testing. Besides, the biotic indices were reported to offer more ecological realism than the bioassay monitors. However, the accuracy of single species bioassay is greater than that of multiple species (population or community) biotic indices. Moreover, the species identification in case of single species analyses is rather easy compared to that of multiple species tests which pose difficult problems.

All the three groups of organisms — microorganisms, plants and animals can be indicators of environmental quality, particularly pollution caused by hazardous substances even in very low concentrations [23]. Among animals, except on a few aquatic invertebrates [8], very little information is available on other animals as indicators of environmental quality. Nevertheless, earlier studies used the species lists to indicate the changes in the environment and accordingly the designations- "very abundant", "common" and "occasional" while tubulating the relative abundance of species in relation to the type and intensity of pollution. Specific organisms such as *Carchesium*, *Epistylis* and *Sphaerotitus* were first used as indicators of sewage pollution [7]. Later, however, it was suggested that not only the whole organism but also the biochemical, physiological, cytological and karyological changes in the animal's body due to the effect of toxic pollutants [5, 23, 27] and their bioaccumulation (biomagnification) [4, 24] may give clues regarding the environmental quality and indicate the presence of different pollutants in the environment.

Information on terrestrial invertebrates particularly the arthropods as indicators of environmental quality is very meagre, although they possess the requisite characteristics and can give more precise information on the quality of the environment [26]. Almost all the arthropods spend their life cycle either

partially or fully in the soil forming a large reservoir of diversified species along with other soil fauna possessing characteristics of useful bioindicators [9] and can be conveniently used in bioassay, and as bioindicators [13]. The present paper reports on the arthropods as indicators of environmental quality being considered both as biotic indices and bioassay monitors. It reports on Collembola, Cryptostigmata and termites as indicators of different environmental gradients based on the approach of biotic indices, and reviews, in brief, the literature on Cryptostigmata as indicators of air pollution, being considering as bioassay monitors.

Soil arthropods as indicators of environmental gradients

The soil arthropods, particularly the Collembola and Acarina, are ubiquitous in terrestrial ecosystems, being numerous under undisturbed natural conditions and less in the disturbed areas with increased anthropogenic activity. They are available in large quantities, throughout or during most of the periods of the annual cycle and are identified as useful indicators of environmental quality. A study conducted on the population abundance of these micro-arthropods in different parts of the montane city, Shillong (Lat. 25° 34' N; Long. 90° 56' E and altitude *ca* 1250 MSL) (Meghalaya, North East India) in relation to land use-patterns due to the human settlement, revealed that the micro-arthropods were numerous in the areas with minimum use of land and were at low ebb in the areas with intensive land use. The "use-pattern" meant here is the clearing of vegetation and construction of houses, concrete buildings and approach roads, and trampling and other such human activities. Particularly the Collembolan, *Isotoma trispinata* (MacGillivray) a predominant and ubiquitous species present throughout the year inside the city and in the surrounding pine *(Pinus kesiya* Royle) plantations [22] was found sensitive to such use-patterns, being recorded in higher numbers under minimum use-patterns in the parts of the city where there was little construction activity as well as in the outskirts of the city where there were very few number of houses. Interestingly, its population showed considerable decline in the center and different other parts of the city as the use-pattern intensified due to more human settlements. It clearly showed the sensitiveness of the soil micro-arthropod populations, particularly *I. trispinata* to intensive use-patterns, which could be designated as indicators of land use-patterns. It corroborated to the suggestion [17] that the population levels of soil micro-arthropods, particularly the Collembola, may be useful indicators for environmental gradients such as use-patterns in recreational areas.

Investigations conducted on populations of soil micro-arthropods of different "Jhum" fallows (shifting cultivated fields) surrounding Shillong

revealed that the micro-athropods, particularly the oribatid mites, *Galumna* sp. and *Scheloribates* sp. were found as useful indicators of vegetational succession and the presence of considerable decomposed organic matter in the soil of the fallows and their suitability for cultivation. The study monitored the population abundance of these arthropods of the fallows of one, five, ten, fifteen and twenty years of restoration-period, and that of the nearest natural or near-to-natural ecosystem in the locality, and showed that the population of the fifteen and twenty years old fallows is more or less equal to that of the natural system. It indicated that these fallows are more suitable and productive for reuse than the other fallows.

During shifting cultivation, first the vegetation of a natural or near-to-natural area is slashed and burnt, and the area is used for cultivation of various upland crops. The present-day cycle of shifting cultivation does not permit the fallows to experience the proper restoration of organic matter and soil fertility because of the increased human populations leading to the decrease in the ratio of land area to population and the iterated use of the fallows without adequate recovery period. Nevertheless, nowadays, after a short period of recovery and restoration which vary depending on the local population and availability of land, the fallows are used for such cultivation. At this stage, while selecting a fallow for cultivation, — prior to the operations of slash and burning — the population abundances of soil micro-arthropods, particularly the oribatid mites *(Galumna* sp. and *Scheloribates* sp.) per unit area of the fallow (to be reused) may be compared and correlated with those of a natural or near-to-natural ecosystem. If the population abundances of both the Jhum fallow and natural system are found more or less equal then the fallow could be reused, as it was found that the abundance of arthropod populations are indicative of the presence of decomposed organic matter and the soil fertility. The cycle of shifting cultivation permits the arthropods to reestablish in the fallow as the slash and burning practices in the beginning drastically reduce the abundance of arthropod populations. Thus, the number of arthropods are more in fallows with longer cycle of recovery period. In consistence with this, it was emphasised [14] that the soil mite-taxocoenoses and ecological groups could be the indicators of soil fertility and humification rate. Besides, the relative abundance of soil fauna has been reported as indicators of seres in plant succession in pine plantations in central Ontario [18].

Sometimes the soil structures constructed by soil arthropods indicate the presence of the underground minerals or the ground-water at depths. The termite mounds being one of such structures, have been reported as indicators of metalic ore deposits in Southern India and Africa, as these structures were found exclusively in the mineralised areas of chromium, vanadium, copper and lead in Andhra Pradesh (India) and possess more concentrations of the mineral elements compared to the surrounding soils [21].

Soil arthropods as indicators of environmental pollution

Although enough literature is available on the effect of various pesticides on both micro-, and macro-arthropods inhabiting soil [6], there is very little information on them as indicators of environmental pollution. It has been pointed out [19] that there is hardly any information on the animals as bio-indicators of air-pollution. No serious study was conducted specifically on soil arthropods as indicators of environmental pollution till 1978 [10]. Interestingly, the Cryptostigmatid complexes have been reported as bioindicators of radioactive pollution in USSR [12]. Later, the corticolous Cryptostigmatid mite, *Humerobates rostrolamellatus* G. was used for monitoring and mapping the air pollution in Belgium [1, 2], as it was found sensitive to SO_2 under both laboratory and field conditions [15]. In the field a good correlation was found, although rather weak, between the mortality rate of the mites and the average concentration of SO_2 indicating the relationship of the mortality with not only the SO_2 level alone but also with the synergistic effect of different atmospheric pollutants and more generally with the air pollution as whole. Thus, *H. rostrolamellatus* may be a good bioassay monitor and bioindicator of air pollution. Besides, there were two more species of oribatid mites, *Carabodes labyrinthicus* (Michael) and *Dometorina plantivaga* (Berlese) which disappeared at higher level of smoke and SO_2 pollution, and were recorded as bioindicators of atmospheric pollution. The latter species was found in maximum number in least polluted zones.

It is, thus, concluded that the soil arthropods, particularly the Collembola and Acarina, could be good indicators of environmental quality.

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